Exelon Generation

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November 19, 2012
TMI-12-172

10 CFR 50.73

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555-0001

THREE MILE ISLAND NUCLEAR STATION, UNIT 1 (TMI-1)
RENEWED FACILITY OPERATING LICENSE NO. DPR-50
DOCKET NO. 50-289

SUBJECT: LICENSEE EVENT REPORT (LER) NO. 2012-005-00
"Reactor Trip due to RC-P-1C Trip"

This report is submitted in accordance with 10 CFR 50.73 (a)(2)(iv)(A). For additional information regarding this LER contact Mike Fitzwater, Sr. Regulatory Engineer, TMI Unit 1 Regulatory Assurance at (717) 948-8228.

There are no regulatory commitments contained in this LER.

Sincerely,

Mark Newcomer
Plant Manager, Three Mile Island Unit 1
Exelon Generation Co., LLC

MN/mdf

cc: TMI Senior Resident Inspector
Administrator, Region I
TMI-1 Project Manager

IE22
NRR

NRC FORM 366 (10-2010) U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB: NO. 3150-0104 EXPIRES: 10/31/2013

Estimated burden per response to comply with this mandatory collection request: 80 hours. Reported lessons learned are incorporated into the licensing process and fed back to industry. Send comments regarding burden estimate to the Records and FOIA/Privacy Service Branch (T-5 F52), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by internet e-mail to infocollects@nrc.gov, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202, (3150-0104), Office of Management and Budget, Washington, DC 20503. If a means used to impose an information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

LICENSEE EVENT REPORT (LER)

(See reverse for required number of digits/characters for each block)

1. FACILITY NAME	2. DOCKET NUMBER	3. PAGE
Three Mile Island, Unit 1	05000289	1 OF 6

4. TITLE: Reactor Trip Due To RC-P-1C Trip

5. EVENT DATE			6. LER NUMBER			7. REPORT DATE			8. OTHER FACILITIES INVOLVED	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REV NO.	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
									N/A	05000
09	20	2012	2012	- 005 -	00	11	19	2012	FACILITY NAME: N/A	DOCKET NUMBER: 05000

9. OPERATING MODE

N

10. POWER LEVEL

100

11. THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR§: *(Check all that apply)*

- ☐ 20.2201(b)
- ☐ 20.2201(d)
- ☐ 20.2203(a)(1)
- ☐ 20.2203(a)(2)(i)
- ☐ 20.2203(a)(2)(ii)
- ☐ 20.2203(a)(2)(iii)
- ☐ 20.2203(a)(2)(iv)
- ☐ 20.2203(a)(2)(v)
- ☐ 20.2203(a)(2)(vi)
- ☐ 20.2203(a)(3)(i)
- ☐ 20.2203(a)(3)(ii)
- ☐ 20.2203(a)(4)
- ☐ 50.36(c)(1)(i)(A)
- ☐ 50.36(c)(1)(ii)(A)
- ☐ 50.36(c)(2)
- ☐ 50.46(a)(3)(ii)
- ☐ 50.73(a)(2)(i)(A)
- ☐ 50.73(a)(2)(i)(B)
- ☐ 50.73(a)(2)(i)(C)
- ☐ 50.73(a)(2)(ii)(A)
- ☐ 50.73(a)(2)(ii)(B)
- ☐ 50.73(a)(2)(iii)
- ☒ 50.73(a)(2)(iv)(A)
- ☐ 50.73(a)(2)(v)(A)
- ☐ 50.73(a)(2)(v)(B)
- ☐ 50.73(a)(2)(v)(C)
- ☐ 50.73(a)(2)(v)(D)
- ☐ 50.73(a)(2)(vii)
- ☐ 50.73(a)(2)(viii)(A)
- ☐ 50.73(a)(2)(viii)(B)
- ☐ 50.73(a)(2)(ix)(A)
- ☐ 50.73(a)(2)(x)
- ☐ 73.71(a)(4)
- ☐ 73.71(a)(5)
- ☐ OTHER

Specify in Abstract below or in NRC Form 366A

12. LICENSEE CONTACT FOR THIS LER

FACILITY NAME	TELEPHONE NUMBER (Include Area Code)
Michael Fitzwater, TMI Unit 1 Regulatory Assurance Engineer	(717) 948-8228

13. COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT

CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX	CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX

14. SUPPLEMENTAL REPORT EXPECTED

☐ YES *(If yes, complete 15. EXPECTED SUBMISSION DATE)* ☒ NO

15. EXPECTED SUBMISSION DATE

MONTH	DAY	YEAR

ABSTRACT *(Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines)*

On September 20, 2012, Reactor Coolant Pump RC-P-1C at Three Mile Island (TMI) Unit 1 tripped on an apparent differential overcurrent condition 55 seconds after Vital Bus C was secured in support of inverter maintenance. An automatic runback was initiated, but the Reactor Protection System (RPS) actuated on flux to flow imbalance and the reactor tripped at 14:17:34. The RC-P-1C trip was attributed to the differential overcurrent condition due to a differential overcurrent relay (ITH 87 relay) for the RC-P-1C, "C" phase operational indicator being flagged. Complex troubleshooting was performed with an emphasis on an RC-P-1C Motor or RC-P-1C\87 Differential Relay failure as the probable cause; however, the troubleshooting did not reveal a definitive cause of the initiating RC-P-1C trip. An operational decision evaluation was performed to assess plant restart without identifying the cause of the RC-P-1C trip during the complex troubleshooting. A subsequent investigation was performed to determine why RC-P-1C tripped but could not determine a definitive root cause. The most likely causes were addressed by the replacement of the relay, adjusting the trip setpoint, and eliminating this type of vital bus outage at power.

This LER is being submitted pursuant to the requirements of 10 CFR 50.73 (a)(2)(iv)(A).

A. EVENT DESCRIPTION

Plant Conditions before the event:

Babcock & Wilcox – Pressurized Water Reactor – 2568 MWth Core Power
Date/Time: September 20, 2012 / 14:17 hours
Power Level: 100% steady state power
Mode: Power Operations

Event:
On 09/20/12, Reactor Coolant Pump RC-P-1C at Three Mile Island (TMI) Unit 1 tripped on an apparent differential overcurrent condition 55 seconds after Vital Bus C was secured in support of inverter maintenance. The Integrated Control System (ICS) initiated an automatic runback, but the Reactor Protection System (RPS) actuated on flux to flow imbalance on channels "B" and "D" and the unit tripped at 14:17:34. The RC-P-1C trip was attributed to a differential overcurrent condition due to a differential overcurrent relay (ITH 87 relay) for the RC-P-1C with the C phase operational indicator flagged. Complex troubleshooting was performed with an emphasis on an RC-P-1C Motor or RC-P-1C\87 Differential Relay failure as the probable cause. The complex troubleshooting plan that was implemented during the evolution did not reveal a definitive cause of the initiating RC-P-1C trip. An operational decision making evaluation (ODM) was performed to assess plant restart without identifying the cause of the RC-P-1C trip during the complex troubleshooting.

Background:
The RC-P-1C Motor is different from the other three RCP motors. It is a JSPM motor supplied by AREVA and installed during TMI refueling outage T1R19 in 2011. The RC-P-1C Motor was replaced as part of the ongoing motor refurbishment project at TMI.

The RC-P-1C had operated satisfactorily throughout cycle 19 for approximately 300 days until shutdown for the Pressurizer heater bundle leak outage in August 2012. No issues were noted during the shutdown and restart of the pump for the outage.

On 09/09/12, the planned maintenance activity for Inverter 1C required the transfer of Vital Bus C (VBC) to Inverter 1E. This operation was performed without incident. On 09/20/12, the operation was in progress to return the VBC to the 1C Inverter by removing VBC from the 1E Inverter when the RC-P-1C trip occurred, as described in the summary above. A detailed review of the specific procedure steps was performed as part of the review. There were no unexpected or abnormal responses identified. No maintenance activities were performed between 09/09/12 and 09/20/12 associated with the relay or motor. Performance of the VBC transfer on 09/20/12 while online should not have been an operational issue.

After the trip on 09/20/12, complex troubleshooting was performed and the results identified three causes with the highest probability: 1) 1C/87 differential relay failure; 2) 1C/87 relay current loop/wiring/connection issue; 3) 1C motor/breaker/feeder cable issue.

Differential Current Relaying Systems are used for protection of the TMI Reactor Coolant Pump Motors from internal winding faults in each of the 3 phases of the motor. The specific 87 Relay, component number RC-P-1C\87, was found with 1 out of 3 flags dropped; specifically, the C phase. This indicates that a current imbalance greater than 250mA, the setpoint of the relay at the time of the trip, occurred within the overcurrent relay's "protection zone." During troubleshooting performed, no abnormal readings were noted.

Offline Motor testing results were obtained after the Reactor trip on 09/20/12 and were compared with offline motor data obtained after RC-P-1C motor installation in November 2011. Test data included: Coil resistance data comparison, Megger and PI Ratio data comparison, and, Step-Voltage Test data comparison. Based on the testing performed on the motor from the switchgear, there were no signs of adverse conditions observed on the test data and no adverse trends were noted during the comparison of the data from 2011 and 2012.

Online Motor Testing results were also reviewed as part of the investigation to determine adverse changes on motor performance that may provide additional information regarding the cause of the trip. Motor parameters in 2011 are similar to data obtained after the plant trip on 09/20/12. This information further supported that the RC-P-1C motor is operating as designed with no adverse trends or conditions observed.

The effect of a less-than-optimal connection at the ITH (Westinghouse relay model number) relay terminal #7 was reviewed. A postulated failure mode is that the connection at relay terminal 7 caused an intermittent circuit, and that the repeated interruption and re-establishment of current in this circuit caused the ITH relay plungers to bounce until one of them tripped. This is viewed as unlikely, due to the following:

A relay calibration check, on the RC-P-1C\87 relay that was found with the C flag triggered, was performed. The ITH relay was original equipment with no indication or necessity to replace based on preventative maintenance history. The calibration performed indicated that the relay was within calibration requirements; however, the relay was removed from service and replaced as a preventative measure. The removed 87 relay was quarantined and sent to Exelon PowerLabs for further analysis.

The PowerLabs conclusion was that the relay functionally operated satisfactorily, but did have a few characteristics that were out of tolerance or unsatisfactory including a low dropout (relay resetting issue) on the #1 (A phase) unit and an erratic higher contact resistance on both #1 (A phase) and 1 of the #3 (C Phase) trip contacts. The higher resistance on both #1s for the "A" phase could have prevented the "A" phase from actuating; however, the relay would continue to work for phase-to-phase protection. None of these issues would have prevented operation or caused a premature or spurious trip.

The relay was challenged by applying current slightly below pickup and mechanically agitating the testing surface and relay directly, but this did not produce any feasible trips. Disassembly and visual examination of the relay under magnification revealed that the plating on the studs, which secured the contact pad/screw terminal pieces to the plunger assembly, was flaking. There was no evidence of these flakes found on or around the contacts or silver discs. Additionally, the scenario to create a trip would involve flakes migrating inward towards the contact - disc gap and bridging two gaps at the same time to create a

contact closure. This scenario is improbable, making the flakes an unlikely cause for the spurious trip. There were no other degraded conditions that would explain the plant trip or any foreign material affecting operation or proper reset.

There was insufficient evidence to conclusively point to interference or contact from neighboring electrical systems as a cause of the RC-P-1C trip.

An operational decision making evaluation was performed to assess plant restart without positively identifying the cause of the RC-P-1C trip during the complex troubleshooting.

B. CAUSE OF EVENT

Subsequent investigation was unable to determine a definitive cause for the RC-P-1C trip. The most likely causes are listed as follows.

RC-P-1C\87 Differential Relay Failure causing spurious actuation
The subject relay was manufactured in 1969, and was 43 years old. This component is not obsolete; new ITH relays are still available. The PowerLabs analysis showed several areas where this relay is showing signs of aging. This is the first unexplained RC Pump differential trip at TMI; operational history has demonstrated dependable reliability, and industry OPEX on other similar indeterminate failures indicates no age related correlation. Several events were identified where the Reactor Coolant pump motor tripped unexpectedly with causes attributed to the differential relay actuation. Although the event could not be reproduced, the relay was replaced and there were no reports of recurrence. Therefore, based on the elimination of other causal factors and age of the relay, this is the most likely cause. This relay has been replaced.

RC-P-1C\87 Differential Relay Current Loop Wiring/Connections including Penetration Connections and CT
Troubleshooting was performed to verify the integrity of the wires including the CT that provides a signal to the 87 relay. Resistance measurements performed verified that there were no other grounds within the circuit. In addition, the resistance readings from the switchgear were a consistent 1.63 ohms per phase.

Visual inspection was also performed inside the motor connection box. No adverse conditions were identified on the wires and current transformers. A walkdown was performed of the cable trays from the switchgear to the containment penetration with no abnormal conditions identified.
Monitoring was performed on the 87 relay input currents after RC-P-1C re-start. No adverse conditions or trends were observed that indicated degradation on the CTs and the wires feeding the 87 relay.

RC-P-1C Motor/Breaker and Feeder Cable Failure
Baker Offline Testing was performed after the RC-P-1C trip which confirmed that there were no phase-to-phase and phase-to-ground faults. Baker Online Testing was performed after motor start-up that confirmed acceptable motor parameters. Comparison of test data obtained after motor installation and the recent plant trip did not identify adverse trends and adverse changes on the motor and feeder cables. Although motor and cable failure may cause the feeder breaker to trip, such failures will typically cause visible damage to the affected component. Inspections inside the motor connection box and electrical testing performed from the switchgear did not indicate evidence of motor or cable failure.

The RC-P-1C breaker was cycled 3 times in its test position without ITH relay actuation.
The RC-P-1C motor was re-started and monitored with no signs of adverse conditions. The continuation of monitoring has provided no evidence of adverse conditions.

C. ANALYSIS / SAFETY SIGNIFICANCE

There were no resulting personnel, off site radiological, or environmental safety concerns created by this event. The RC-P-1C trip did not pose a threat to reactor safety.

Risk Assessment:
The investigation performed for the 09/20/12 Reactor Coolant Pump trip did not provide the specific cause of the transient. No definitive root cause has been determined, as extensive relay testing has not produced any failure and investigated motor issues have been evaluated as low probability. Operating experience review has shown that cause determinations can be elusive for these and similar types of relays. Therefore, the cause analysis leads toward addressing the most likely causes by replacing the original plant equipment relays with new relays to mitigate age as a cause. Additionally, raising the relay setpoint to minimize the occurrence of a spurious trip and rescheduling Vital Bus transfer activities that could impact RCP motors or relays during plant operation, provide reinforced barriers to an inadvertent RCP trip.

Following the RC-P-1C trip, an operational decision making (ODM) process was commenced and the suspension of on-line inverter maintenance was initiated. The decision was made to initiate plant criticality with no confirmed cause of the event. The decision was based on bounding all high probability possible causes for the event initiation, reducing operational risk. An Adverse Condition Monitoring Plan (ACMP) was put into place to continuously monitor the CT inputs to the differential current relay with action limits established to bypass the relay on any abnormal indications of noise. The ITH 87 relay was replaced. The refurbished relay's setpoint was increased from 250mA to 500mA to provide additional margin while the removed relay was subjected to PowerLabs analysis. The RCP motor was subjected to Baker online and offline testing, Megger and PI testing all of which confirmed that the motor is consistent and performing as designed. The test data indicates that the Insulation Resistance and the Polarization Index of the motor are consistent with the recommended values of IEEE-43-2000.

A risk assessment concluded that no potential cause of the unexplained adverse conditions create any condition outside of the design functions of the RCPs or the RPS. Trips of the relays or the RCP motors will cause a plant trip, but all safety system functions remain as designed. Operational risk has been reduced by the replacement of the relay, adjusting the trip setpoint, and eliminating this type of vital bus outage at power.

D. CORRECTIVE ACTIONS

- Replaced differential relay RC-P-1C\87, and, established plans for replacement of RC-P-1A\87, RC-P-1B\87, and RC-P-1D\87
- Established plans to megger RC-P-1C\87 CT circuits and RCP-1C Reactor Coolant Pump Power Monitor (RCPPM) CT and PT circuits

E. PREVIOUS OCCURENCES

A search for relevant OPEX led to several other industry events where reactor coolant pumps tripped with no obvious cause. These were at Wolf Creek (1990, event #90582), St. Lucie (2001, event #192708) and Catawba (2003, event #207852). The Catawba and St. Lucie events appear to have been events of unknown cause which were attributed to differential relaying based on prior OPEX with older versions of the solid-state differential relays used at these plants. The St. Lucie event makes no mention of a trip indication and the Catawba event specifically states that there was no differential relay trip indication. These events do have some relevance, as they are unexplained RC pump trips and these sites did make further causal investigations. In each of the above events, the differential relays were replaced as a conservative measure, although testing could not produce a failure.

Previous Events	Previous Event Review
TMI-1 Circa 1982 RC-P-1 Trip when breaker cubical door is opened	During shutdown conditions a Start-up & Test technician opened a RC pump breaker cubical door and the RC pump breaker tripped. During the opening of the door the upper portion of the door caught, due to friction, and then released causing the door to vibrate (twang). The 87 relay flag(s) indicated tripped. Relevance to TMI – This indicates that the 87 relay has sensitivity to vibration; however, there is no evidence of personnel in the area of the switchgear at the time of this trip. Also the following tests indicate that this sensitivity is relatively low: 1. The Power Labs report states: "The relay was not unusually susceptible to vibration or mechanical agitation. During the complex troubleshooting the breaker was cycled three times in the test position and the 87 relay did not trip. Also the door was opened and closed three times and the 87 relay did not trip.

* Energy Industry Identification System (EIIS), System Identification (SI) and Component Function Identification (CFI) Codes are included in brackets, [SI/CFI] where applicable, as required by 10 CFR 50.73 (b)(2)(ii)(F).